Welcome to FLS 2010

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March 1, 2010

SLAC NATIONAL ACCELERATOR LABORATORY

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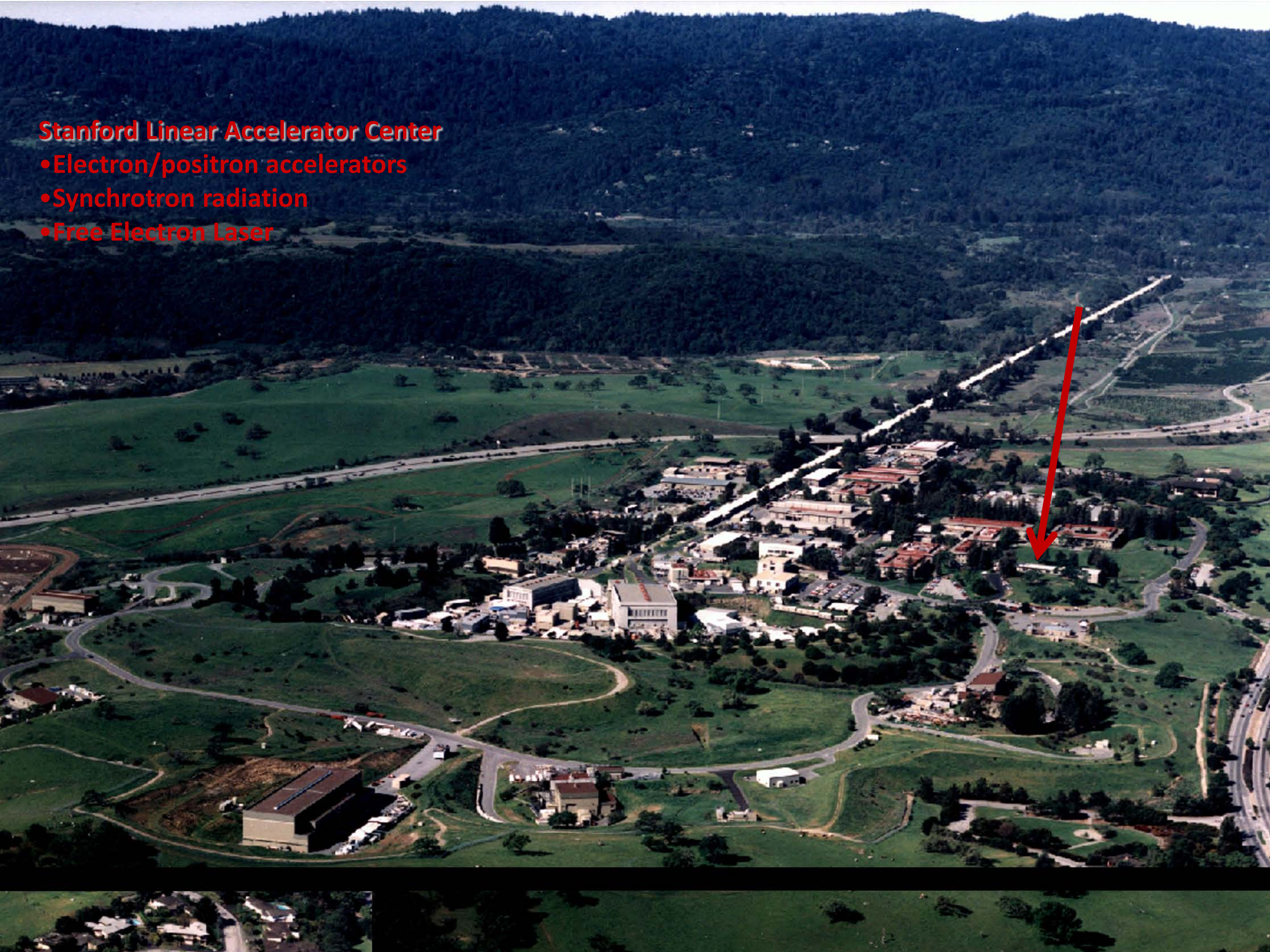
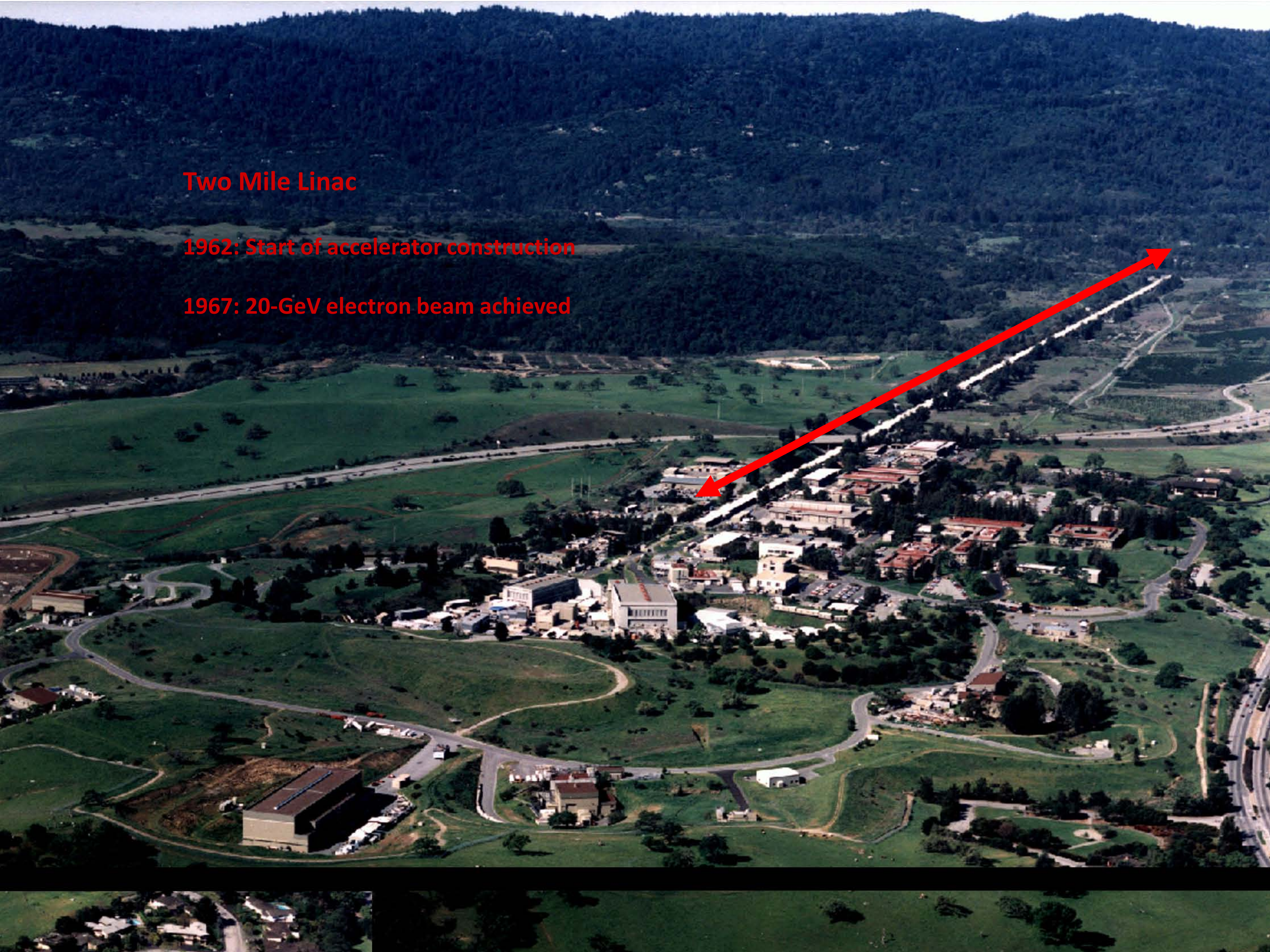
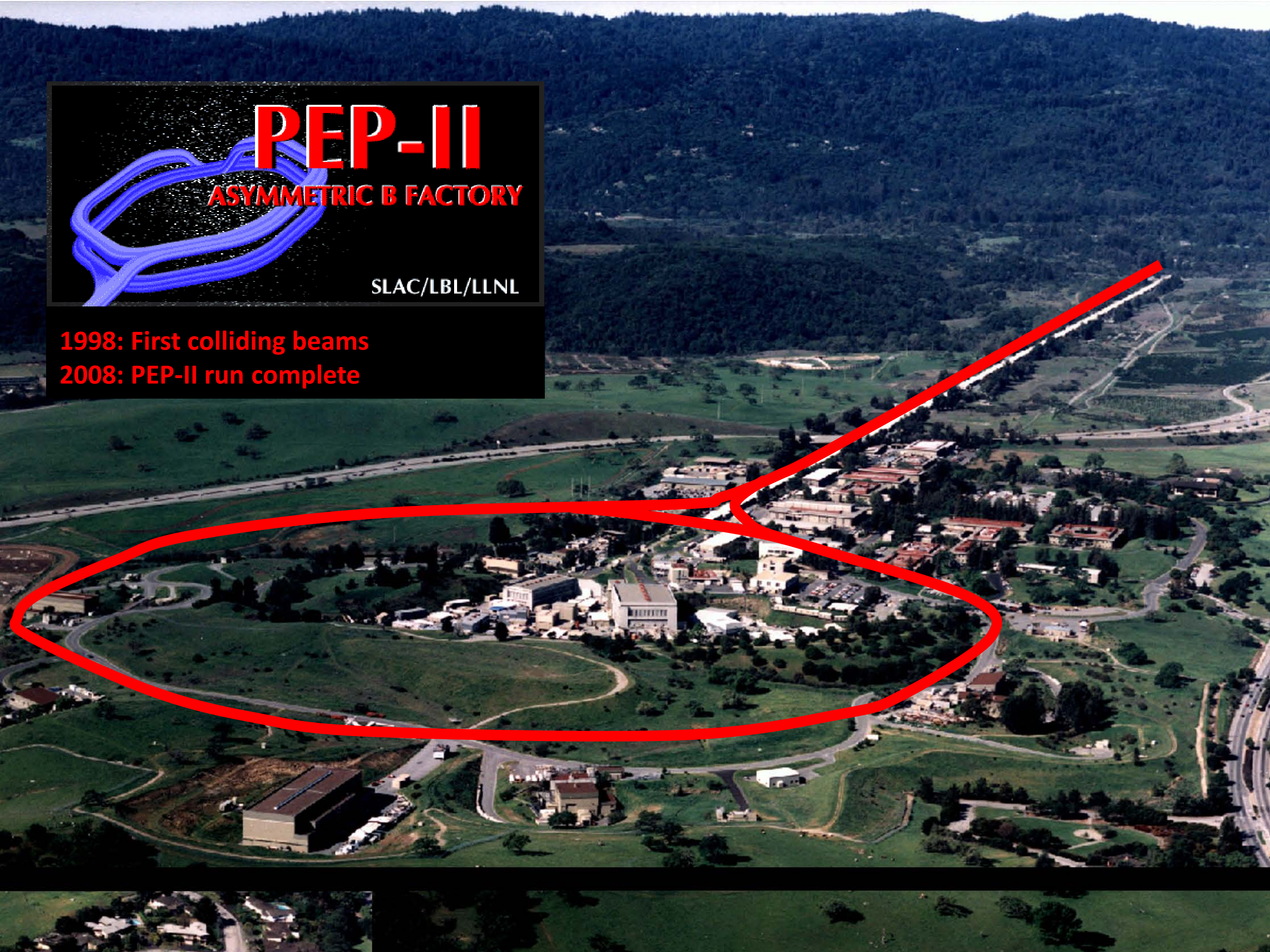
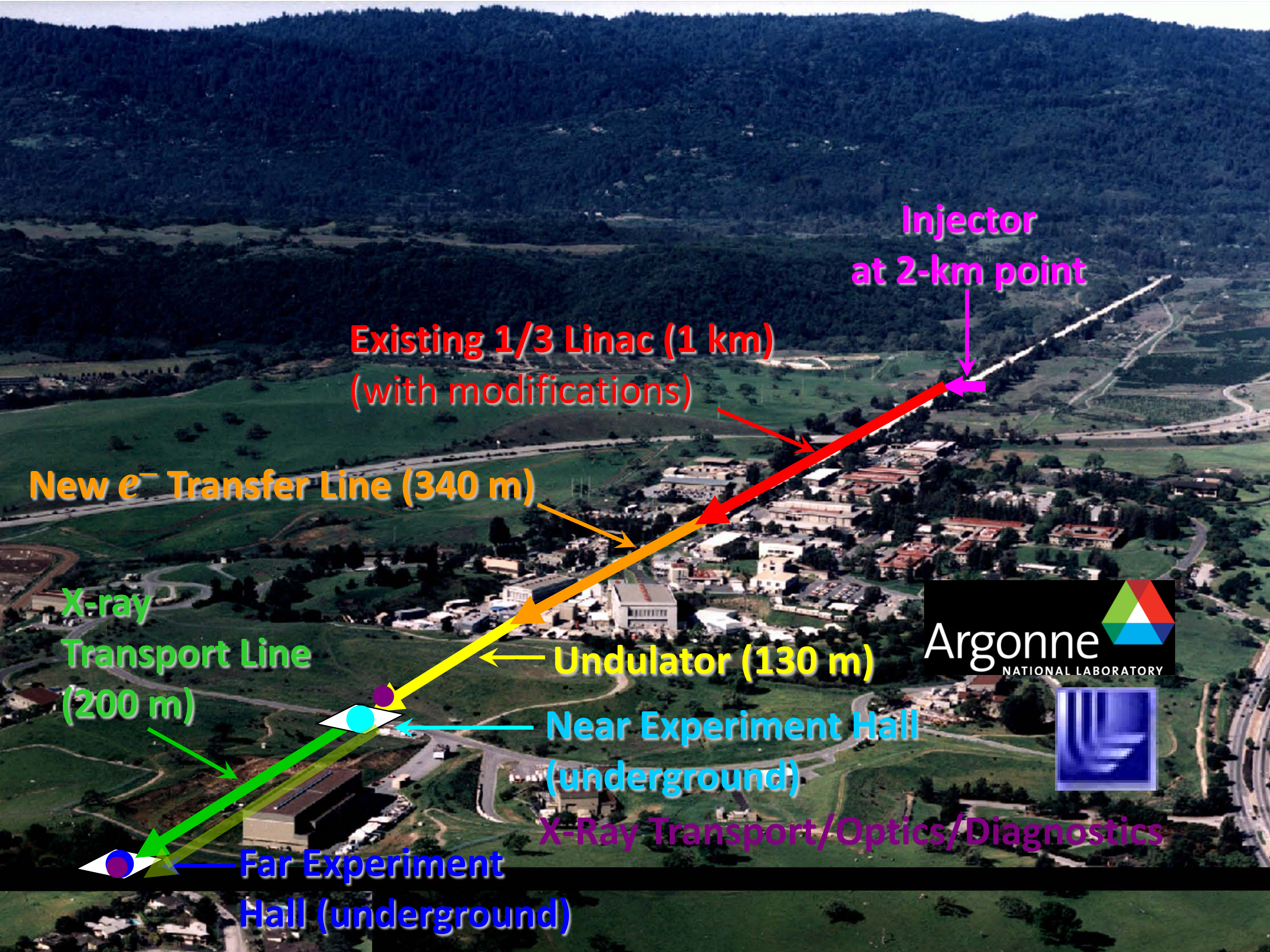

Stanford Linear Accelerator Center
•Electron/positron accelerators
•Synchrotron radiation
•Free Electron Laser

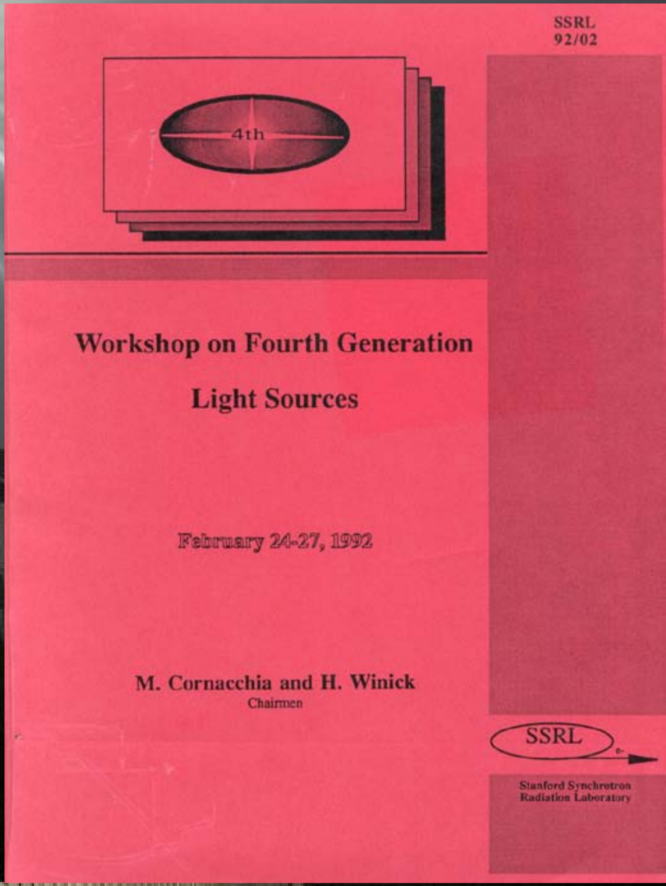

Two Mile Linac
1962: Start of accelerator construction
1967: 20-GeV electron beam achieved


PEP-II
ASYMMETRIC B FACTORY
SLAC/LBL/LLNL
1998: First colliding beams
2008: PEP-II run complete

SPEAR 3.7 GeV Storage Ring and Synchrotron Radiation

1972: SPEAR operations begin
1973: Stanford Synchrotron Radiation Project (SSRP) started – First Light
1977: SSRP becomes Stanford Synchrotron Radiation Laboratory (SSRL)
1990: SPEAR II - a dedicated synchrotron radiation facility
2005: SPEAR III synchrotron source


Injector
at 2-km point
Existing 1/3 Linac (1 km)
(with modifications)
New e^- Transfer Line (340 m)
X-ray
Transport Line
(200 m)
Undulator (130 m)
Argonne
NATIONAL LABORATORY
Near Experiment Hall
(underground)
X-Ray Transport/Optics/Diagnostics
Far Experiment
Hall (underground)


SSRL 92/02

4th

Workshop on Fourth Generation Light Sources

February 24-27, 1992

M. Cornacchia and H. Winick
Chairmen

SSRL

Stanford Synchrotron Radiation Laboratory

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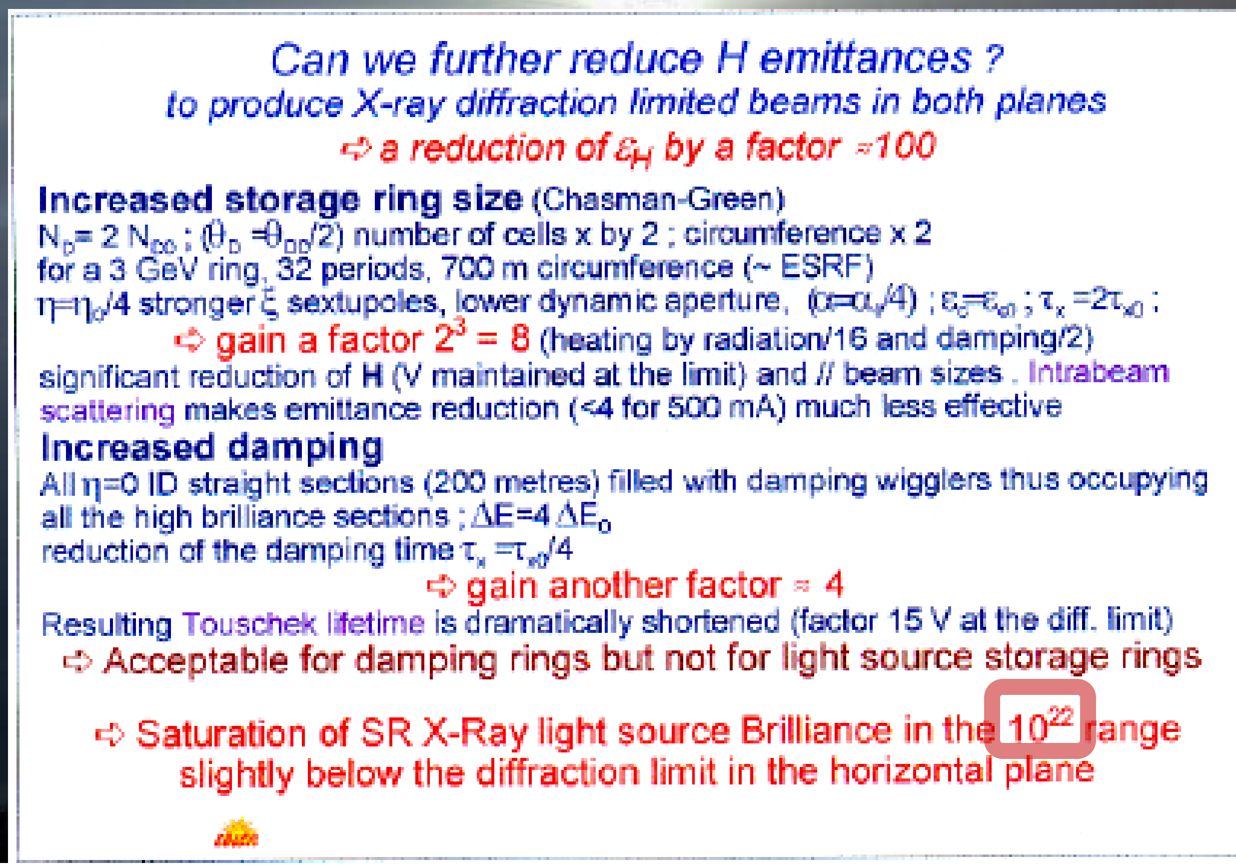
FLS 1996, Summarized by J. L. Laclare
At FLS 1999

Future Storage Rings as viewed in 1996:

Future Storage Rings can exceed 10^{22} via
- -Large circumference
- -Damping wigglers
- -On-axis injection



Can we further reduce H emittances ?

to produce X-ray diffraction limited beams in both planes

⇨ a reduction of ε_H by a factor ≈100

Increased storage ring size (Chasman-Green)
$N_D = 2 N_{DD}$; ($\theta_D = \theta_{DD}/2$) number of cells x by 2 ; circumference x 2
for a 3 GeV ring, 32 periods, 700 m circumference (~ ESRF)
$\eta = \eta_0/4$ stronger ξ sextupoles, lower dynamic aperture, ($\alpha = \alpha_0/4$) ; $\varepsilon_\delta = \varepsilon_{\delta 0}$; $\tau_x = 2\tau_{x0}$;
⇨ gain a factor $2^3 = 8$ (heating by radiation/16 and damping/2)
significant reduction of H (V maintained at the limit) and // beam sizes . Intrabeam scattering makes emittance reduction (<4 for 500 mA) much less effective

Increased damping
All $\eta=0$ ID straight sections (200 metres) filled with damping wigglers thus occupying all the high brilliance sections ; $\Delta E = 4\,\Delta E_0$
reduction of the damping time $\tau_x = \tau_{x0}/4$
⇨ gain another factor ≈ 4
Resulting Touschek lifetime is dramatically shortened (factor 15 V at the diff. limit)
⇨ Acceptable for damping rings but not for light source storage rings

⇨ Saturation of SR X-Ray light source Brilliance in the 10^{22} range slightly below the diffraction limit in the horizontal plane

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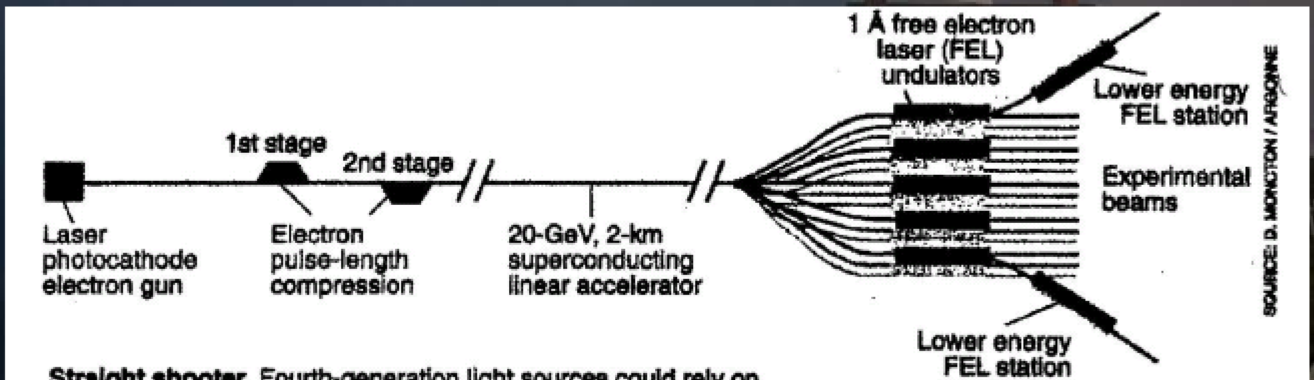
FLS 1999
Ring Working Group
summarized by
M. E. Couprie

-Large circumference
-Damping wigglers
-Top-up injection

Lattice optimizations and reduction of emittance were discussed. The finite dispersion lattice modes have become very popular, and are shown to give more than a factor of 2 emittance reduction. At ESRF, the radiation emitted from a point upstream of the electron beam waist naturally converges further downstream (by moving the waist further downstream than the centre of the straight) and allows the brilliance to be increased by a factor of 2. As a further step, a sketch of a future storage ring-based source was proposed. Based on a twice APS/ESRF type machine including damping wigglers, it presents a circumference of 2 km, more than 30 6- meter-long straight sections for insertion devices, the rest of the machine being occupied by wigglers and rf cavities. The emittance can be reduced down to 20 pm because of the doubling of the circumference, the choice of an energy of 4 GeV, and the use of damping wigglers. With a stored current of 2A in 2000 bunches with a main 350-MHz cavity, the brilliance is 10^{24} at 1 Å, i.e., 4 orders of magnitude higher than the operating facilities. The lifetime reduction (1h) is overcome by topping-up. In order to avoid intrabeam scattering, the machine is operated at full coupling, and the bunch is lengthened with a harmonic cavity. This brilliance improvement of four orders of magnitude is achieved with well-known lattices and standard techniques.

FLS 1996, Summarized by J. L. Laclare
at FLS 1999

XFEL concept marked a distinct change in attitude among x-ray researchers, at least where I was sitting at the time



Straight shooter. Fourth-generation light sources could rely on linear accelerators and free-electron lasers.

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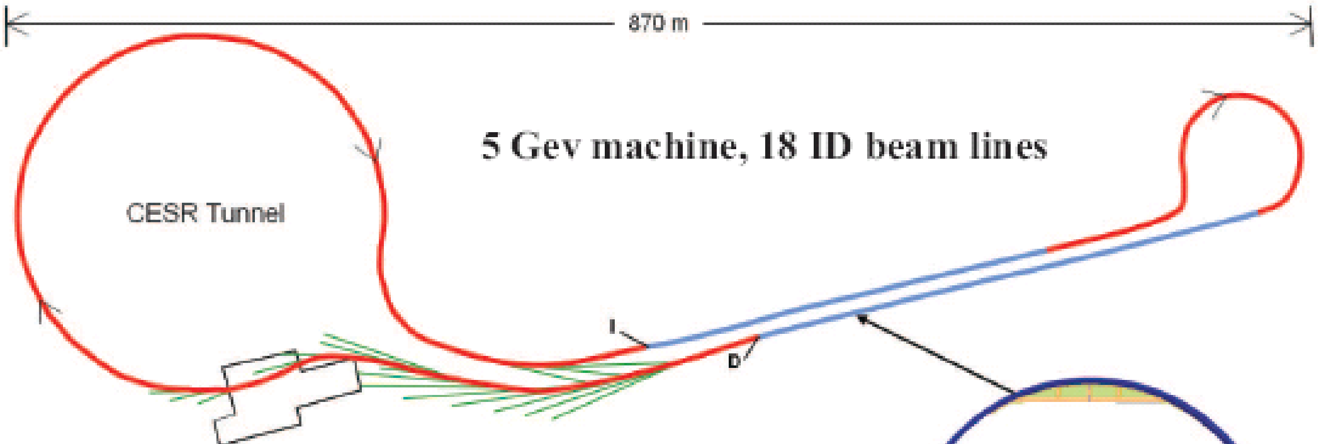
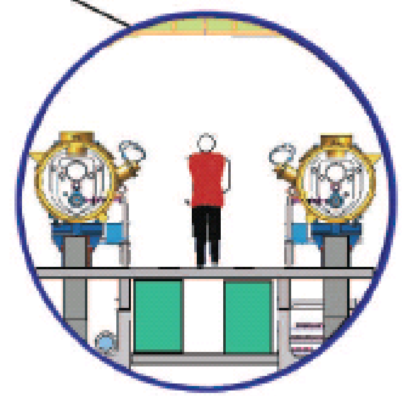
ERLs – flexible optics, smaller energy spread in electron beam, short pulses

No sextupoles!

Can support FELs too



Preliminary layout view of an ERL upgrade to CHESS in the present CESR tunnel. A new tunnel with a return loop will be added to CESR. Electrons are injected into superconducting cavities at (I) and accelerated to 2.5 GeV in the first half of the main linac, then to 5 GeV in the second half. The green lines show 18 possible beamline locations. Electrons travel around the CESR magnets clockwise and re-enter the linac out of phase. Their energy is extracted and the spent electrons are then sent to the dump (D).



Two superconducting linacs in one tunnel accelerate the electrons to 5 GeV. Person shown for scale.

3 Basic Operating Modes

Hi-flux: 30 pm emittance, 100 mA, 77 pC, 1300 MHz repetition rate
electron energy spread of 2E-4 (5 pm, 100 mA long-term goal)
Hi-coherence: 8 pm, 25 mA, 7.7 pC, (5 pm, 100 mA long-term goal)
Ultra-fast: 511 pm, 1 mA, 1 nC, 1 MHz repetition rate

Bilderback, FLS 2006

FELs

Beyond SASE
-Seeding, temporal coherence
-challenges: electron beam is not
 a piece of ruby – Fourier transform limit?
-"cavity" FEL for hard x-rays revisited

New x-ray experimental techniques
-agile change in pulse duration
-agile change in wavelength
-Seeding/modulation for lock-in timing

Future research opportunities with FELs can be profoundly influenced by the first generation of x-ray FEL experimenters!

Dialog with the accelerator builders to exploit new ideas emerging from early experience with FELs

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